

APPENDIX C

DESIGN GUIDANCE FOR CONDUITS THROUGH LEVEES

C-1. General. Reinforced concrete pipe (RCP) should be used as conduit through urban levees and any other levees where loss of life or substantial property damage could result from an embankment failure. Corrugated metal pipe (CMP) may be used as an option on agricultural levees. A life cycle cost (LCC) analysis should be made when the CMP option is used. Inlet structures, gatewells, and outlet structures should be cast-in-place reinforced concrete, except that precast concrete or corrugated metal structures may be used in levees when the criteria contained herein are satisfied.

C-2. Reinforced Concrete Pipe. Reinforced concrete pipe with either steel or concrete bell-and-spigot surfaces and solid-ring rubber gaskets should be used. The RCP should generally comply with the requirements of "AWWA Standard for Reinforced Concrete Pressure Pipe, Noncylinder Type, for Water and Other Liquids" (AWWA C302) or ASTM C-76. The pipe should satisfy the D-load as determined by EM 1110-2-2902 and the hydrostatic pressure test required for the project. Steel joint rings should be used at the gatewell and at gated outlet structures to assure a water-tight system. Steel skirts and anchorage are required for the steel joint rings.

C-3. Corrugated Metal Pipe. Corrugated metal pipe may be used on agricultural levees where pipe diameters do not exceed 36 inches and levee embankments are not more than 12 feet above the pipe invert. Pipe diameters exceeding 36 inches but less than 60 inches may be used if a detailed investigation of service conditions and safety requirements, including submergence head, duration of flooding, joint connection details, and consequences of failure, is conducted in consultation with and approved by CEEC-ED. The pipe diameters larger than 60 inches should not be used. The CMP should satisfy the external load and the hydrostatic pressure test required for the project. Generally, a minimum of one CMP replacement should be considered during the life of a project. CMP connections should follow the following guidance:

a. The connecting joints for annular and helical CMP under levees should be flexible watertight and rubber-type gasketed joints. For lateral pipe; outside the levee, standard field joints may be used,

b. The gaskets should be either sleeve type or "O" ring type. Sleeve type gaskets should be closed-cell neoprene, skin on all four sides. They should meet the requirements of ASTM D-1056, Grade 2C2, and should be of one-piece construction. The thickness should be 3/8 inch and the width should be 1/2 inch less than the width of the connection band required. "O" ring type gaskets should meet the requirements of ASTM C-361.

c. A hydrostatic test, as specified in Guide Specification, CE 02501, should be made in the field.

d. The connecting bands should be either the hugger or corrugated type. Both should be used with rod and lug fasteners, and should be two gages lighter than the pipe specified, but not less than 16 gage.

(1) Hugger Band Type (Figure C-1). The hugger type band should be 10-1/2 inches wide and should have two 1/2 inch deep corrugations spaced 7-5/8 inches apart. The two corrugations should mesh and fit with the second annular corrugation of the pipe end. The band should be essentially flat across the "O" ring gaskets and should be drawn together by two 1/2 inch bolts through the use of a bar and strap suitably welded to the band. The band should be secured with two 1/2 inch diameter circumferential rods and cast-iron, silo-type lugs. The band should be of the same material and coating as the pipe specified.

(2) Corrugated Band Type (Figure C-2). The bands should not be less than 12 inches wide. Bands should be secured with 1/2-inch diameter circumferential rods and cast-iron, silo-type lugs. A minimum of 6 circumferential rods per band should be used. Bands should be of the same material and coating as the pipe specified. They should provide a minimum circumferential lap of 3 inches and be formed to fit and mesh with the corrugations of the pipe to be connected.

e. Circumferential rods, lugs, connection angles, bolts, and nuts should be galvanized after fabrication.

f. After installation of the connecting bands, the entire exterior of each joint assembly, including bands, rods, lugs,

bolts, and nuts should be given one coat of cold applied bituminous compound.

C-4. Pipe Laying Lengths. The pipe laying lengths should not exceed 12 feet for conduits where nominal foundation settlement is expected to occur. Lengths should not exceed 8 feet where more than a nominal amount of foundation settlement is expected. Two half lengths of pipe should be used at both the upstream and downstream end of the gatewell and any other location where there is a change in the foundation condition.

C-5. Concrete Cradles. A concrete cradle should be provided both upstream and downstream of the gatewell for the first length of pipe. It should be dowelled to the gatewell with allowance for slight deflection. Bedding that is disturbed for more than one foot along the pipe should be backfilled with lean concrete, with allowance for rotation at the pipe joints. Compacting bedding under an installed pipe is not permitted. Concrete cradles should be continuously reinforced in the longitudinal direction with temperature and shrinkage reinforcement. The steel area provided in both directions should be 0.002 times the area of the concrete. The steel area in the transverse direction should be based on the thickness below the invert of the pipe. Dowels across a joint in the cradle should be adequate to transfer the shear capacity of the cradle, or the maximum differential load anticipated if excess cradle capacity is provided. A compressible material, usually 1/2 inch thick, should be used in the joints to allow for slight deflection.

C-6. Joint Collars. Joint collars are generally not required. They may be used where considerable outward movement of the levee is expected to occur. When used, they should be isolated from the pipe with compressible material to allow for slight deflection.

C-7. Cutoff Collars. Cutoff collars inhibit good mechanical compaction of the backfill and should not be used.

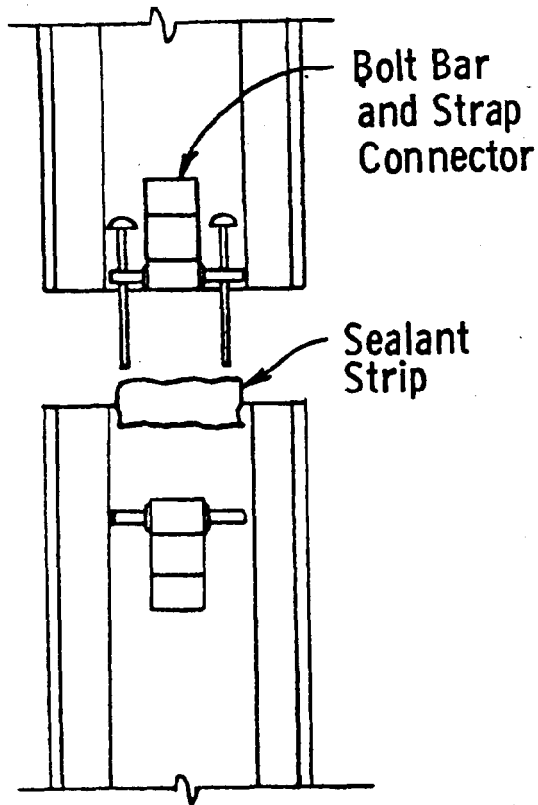
C-8. Field Joint Tests. Hydrostatic tests should be made on all joints after the pipe is installed but prior to placing the joint collars and any backfill except that required for bedding the pipe. The water pressure for the test should be 120 percent of

the maximum pressure anticipated during the life of the project. Defective pipe or joints disclosed in the hydrostatic test should be replaced and the test repeated until satisfactory results are obtained. See AWWA C302 for general guidance on hydrostatic pressure tests.

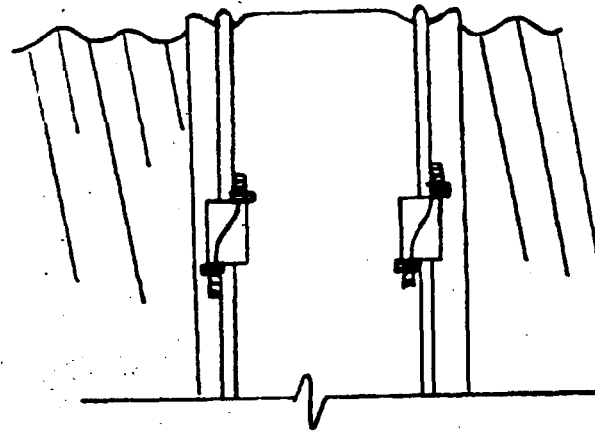
C-9. Gatewells. Cast-in-place concrete gatewells are preferred because of their structural integrity. Precast concrete gatewells may be used in lieu of cast-in-place concrete if designed and detailed to satisfy the loading and functional requirements. The loading requirements must include the maximum loads that can be applied through the gate lifting and closing mechanism. These mechanisms are usually designed with a factor of safety of five. This will usually require mechanical connections between pipe segments and additional longitudinal reinforcement in the pipe. The top, bottom, and gate frame must be securely anchored to resist all loading conditions. The joints for the gatewell should be the same type as used for the pipe conduit. The installed gatewell should be subjected to a hydrostatic test prior to backfilling. Corrugated metal gatewells may be used in lieu of cast-in-place concrete where CMP conduits are permitted, if designed and detailed to satisfy the same requirements as precast gatewells.

C-10. Inlet Structures. Cast-in-place reinforced concrete or precast concrete inlet structures should be used. Corrugated metal inlets may be used in lieu of cast-in-place concrete or precast concrete where CMP conduits are permitted, if designed and detailed to satisfy the loading and functional requirements.

C-11. Outlet Structures. Outlet structures are normally cast-in-place reinforced concrete U-wall structures. Pile bent supports are permissible for not less than 16 feet of pipe at the outlet end, with the flap gate securely attached to the pipe. The pipe should be securely attached to the pile bents. Two half lengths of pipe should be placed immediately upstream of the pile bent supported pipe. A pile bent supported CMP outlet structure may be used in conjunction with RCP through the levee section.



Connection Detail of
Single Harness (Rod
and lug not shown)



Connection Detail of Rod and Lug

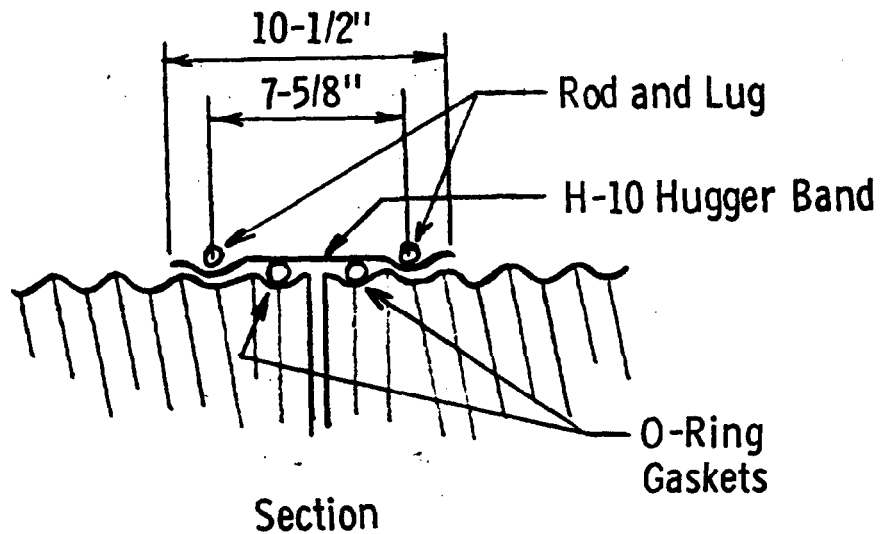


Figure C-1. Hugger Band

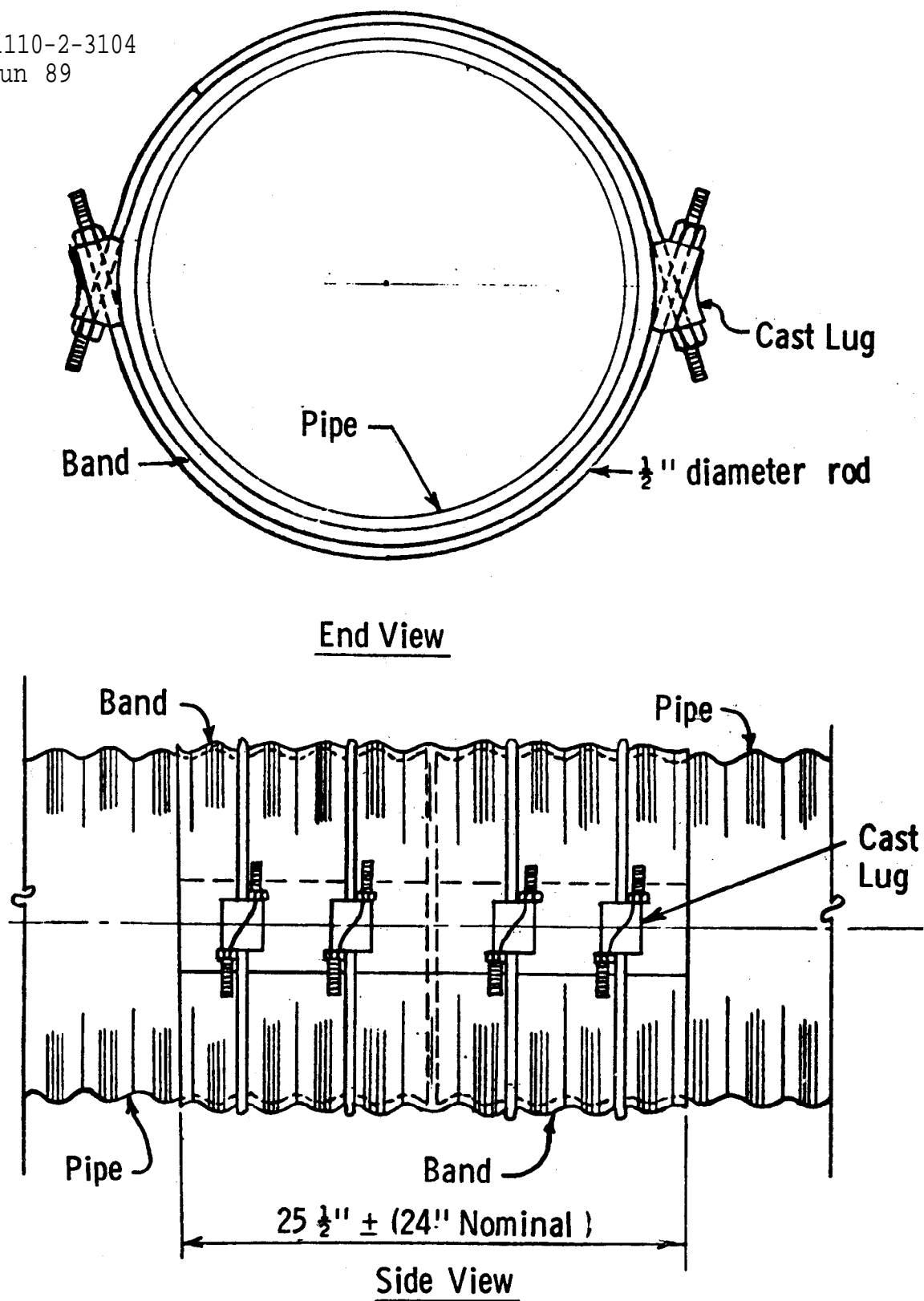


Figure C-2. Corrugated Band